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CHILDREN'S IDEAS ON SOLAR CELLS

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EXPLANATION

The main author of this paper (J.W.) wrote the original as two separate essays for a Bachelor of Education unit at Northern Territory University (The Teaching of Science: EBE 483) for the second author (B.P.). This unit contains as a major component student/teacher research on children's ideas (misconceptions) in science. This paper seems very worthwhile to me (B.P.) as it deals with content (the solar cell) that I have not seen described elsewhere in the research. No listing of research in this area is apparent in recent bibliographies (Pfundt & Duit, 1994; Driver et al, 1995). It is also in keeping with current ideas in the Northern Territory on introducing technology into education at the primary level. The paper continues a series of papers on children's ideas in science that relate to the Northern Territory. (Isaacs, 1992; Palmer, 1993; Gavin 1994; Bonazinga, 1995)

The two essays have been coalesced into a single paper and the resultant article seems to demonstrate to me (B.P.) that children's learning can happen successfully through self-learning as a group. A video was made to show the learning process and although the results are definitely in the amateur category, the video shows children having fun in learning science. Critics viewing the video might well ask "What did the children learn from that?" The answer that they learned a lot is clearly demonstrated by before and after tests, the results of which are included in this paper. It is the comparison of the children's answers before and after the learning experience, that I hope will convince colleagues of the effectiveness of the teaching and learning strategies used in this instance.

Hereafter the use of the first person is reserved for the major author (J.W.)

INTRODUCTION

This is to relate information gathered by myself about children's knowledge and concepts concerning solar cells. Children at primary school level are constantly discovering new ideas and concepts. Previous knowledge and experiences help children to form and discover new concepts in their surrounding environment. They can use a certain block of concepts to help them build another larger concept and from there they can continue to create a 'snow ball' effect of concept building throughout their life. Concepts can and

are used as a tool for dealing with the unknown and extending the known. Children can acquire new concepts, modify old ones or disregard previously learned concepts.

METHOD

I chose the topic of solar cells because they are a common device in our environment today. As I am dealing with year seven students, I assumed that most, if not all, had some experience of solar cells. Many of these students would be aware that they have solar hot water systems on their rooftops or have seen the solar car races on television. This was the reason that I chose to research this topic and I hoped to find out what misconceptions they had regarding what a solar cell was and how it worked.

My method of approach was to give twenty-five year seven students a sheet of paper with questions about solar cells and ask them to write their responses down. I stressed to the children that they should write whatever came into their heads. I also assured the students that all responses would be treated as confidential and there was no need to write their names on the sheet.

As I was planning to teach a unit on solar cells I needed to know what the children already knew so I didn't double up on their knowledge or repeat any work that they had previously completed. My theory was that if I could find out what concepts they already had about solar cells then I could plan what objectives were needed in my unit according to their preconceptions.

Upon reading chapter three of 'The Science Framework' (V.M.E., 1987) which gives examples of finding out about students concepts on a particular topic, I decided to take the approach of simply giving student's questions relating to the topic and interpreting their answers. The children had an unlimited time limit to complete the question sheet but most finished within fifteen minutes. The questions were:

1. What is a solar cell?
2. How does a solar cell work?
3. What is a solar cell made of?
4. What can a solar cell be used for?

The class is made up of twelve boys and thirteen girls. These students vary in ages between eleven and thirteen. Some have a very mature outlook while others are very immature.

RESPONSES PRIOR TO THE VIDEO

Student responses follow under each of the questions.

QUESTION: WHAT IS A SOLAR CELL?
* a tiny bit of metal which can stand heat
* it's like a greenhouse but different
* a panel which uses the sun's energy to make electricity
* don't know
* a small device with an aluminium covering
* wouldn't have a clue
* a material object that uses the sun's light energy for electricity
* a part of a solar panel which stores the sun's energy
* a cell from the sun
* never heard of it
* collects the sun's rays and can power things
* something that is used in solar things like hot water
* something we put on house roofs to heat water
* a cell which can generate energy or heat water
* it is a big plate of glass
* I don't know
* something to do with the making of electricity, In other words I don't know
* a form of energy that can use electricity without polluting
* it soaks up the sun's rays and makes it into energy
* something that runs electricity when the sun shines on it
* a cell found in solar panels
* a cell that makes something move without electricity
* a cell from a solar panel
* It is a cell of solar energy

From the responses gathered it is plain to see that the majority of students can not clearly explain what a solar cell is. Four responses suggested that it had something to do with solar panels. Two responses said that it was a piece of metal or a metallic device. Another four students said they didn't know what a solar cell was, which surprised me. The majority of responses told of what a solar cell could do rather than what it was. These answers explained how a solar cell has something to do with making electricity from the sun. These responses generally indicate a lack of knowledge about what a solar cell is.

As a result it is apparent that most students know that solar cells are associated with the sun and electricity but individuals have very different concepts about how they are associated. Although they are confused about what a solar cell actually is, they appear to be more concerned about what function it actually performs.

QUESTION: HOW DOES A SOLAR CELL WORK?

* by using the heat given by the sun and transforms it into electricity
* by reacting to things what it isn't used to such as pollution
* it takes energy from the sun and makes electricity
* the sun is the main power source for the solar cell. It gets the sun power and puts it in a battery
* comes in contact with the sun
* it collects the sun's rays and turns them into energy
* by sucking or capturing the sun's heat/light which goes through some process to power up electrical things
* by powering or absorbing the sun's heat
* don't know
* electricity, some wires
* collecting the sun's rays and powering things which have a large collection of these cells
* it attracts the sun's rays and it either makes light work or hot water
* it works by the sun. The sun heats it up and while it does it heats up our water to have a shower
* sun reflects its rays on to it and it converts to energy
* it uses the sun's rays " letting out radiation
* the sun hits the solar cell which produces energy
* it works for all of the solar cars and anything that needs solar energy
* absorbing the sun's rays and turning it into energy
* I don't know
* the sun drifts through the cell
* the sun's rays shine through the cells and the object moves without electricity
* u.v. rays hit the panel, it causes an action to start up the panel
* when a lot of solar cells combine, it makes up a large amount of solar energy

The responses given to this question suggest that most of the students already have a simplistic view of how a solar cell works. The majority of responses include key words such as sun, energy, rays, electricity and power. These words were used later when students constructed a concept map. About five answers out of the twenty-five students showed that they had little or no knowledge about how a solar cell worked or they were unable to explain it.

As a result of the responses given here I came to the conclusion that students do not understand the concept as a process of the sun's solar energy being converted into electricity, though they have some limited general understanding.

QUESTION: WHAT IS A SOLAR CELL MADE OF?
* the sun

* sun's u.v. rays and infra red rays
* don't know
* glass, foil
* no response
* no response
* energy from the sun and has a battery type of steel
* I don' t know
* no response
* glass
* glass
* glass
* no idea
* absolutely no idea
* aluminium, metal
* heat waves, light waves
* fibre glass
* solar heat/light waves that capture light
* glass and cells
* aluminium
* glass and tin foil
* metal, plastic, alloy
* ultra violet rays and rocks and atmosphere
* a type of crystal

This list of responses produced a wide and varied range of ideas. A large number of students tended to think that a solar cell was made from glass or a metal. This way of thinking could be attributed to the physical appearance of cells. Some children took the approach that cells had something to do with the sun so they must be made from the sun or it's rays or light. Seven responses stated that they didn't know or they just didn't respond. Only one student stated that it was made from a type of crystal.

This is an area where students appear to have a poor concept of what solar cells are actually made of. Children in this instance tend to state what a solar cell is made of by recalling what one looked like (metallic, glass). Alternatively they may explain what is associated with the workings of it (sun, light, rays).

QUESTION: WHAT CAN WE USE A SOLAR CELL FOR?
* solar powered electricity, growing plants, crops
* to make a solar panel, produce pollution free electricity
* for driving cars
* lighting, telephones, cars, general day electricity
* to run electricity

* heating water, electricity, stove, powering a car, anything
* solar cars
* electricity, mainly light
* melting ice
* heat water, generate power, run cars, use telephones
* heat water, charge up a flat car battery, power lights or power points
* heat up water, make electricity, energy for cars
* hot water, solar cars, lights, something that you build with a solar panel
* solar cars
* hot water electricity
* energy
* cars, water, heaters and energy
* solar panels or solar cars
* to power things to make them run
* help heat water, produce electricity
* power, telephones, water
* electrical devices
* use it for energy and powering things
* creating hot water or for electricity

This question produced some very knowledgeable responses with almost all students being able to give a correct answer. It could however be argued that some students have a limited knowledge of what a solar cell can be used for as a result of giving only one or two examples. Overall the students have created a list detailing a variety of uses of solar cells but the question could be asked whether all the students knew all the uses.

In conclusion to this section it is clear that nearly every child has at least one concept of what a solar cell can be used for however limited this may be but this could be the result of students thinking that only one example was required

FINDINGS

It can be seen from the responses given that these year seven students as a class have a number of misconceptions about solar cells and their characteristics. It is easy to put these misconceptions down as fact but further research and different methods of approach could have been used to achieve a greater insight into what the student's ideas about solar cells are.

I was aware from 'Frameworks' p.32 that "Understanding" is not an all or nothing condition. 'Concept development' is indeed development, with different students progressing at different rates and with wrong turns being a natural and essential part of the process. The focus of teaching and assessment

should be on this process and not on student use of scientific words, which is often a false indicator of achievement. However the findings from the student's answers were used as the basis for devising a plan to teach them more about solar cells. It was thus necessary to see what they understood clearly (conceptions) and what they did not understand (misconceptions).

CONCEPTIONS

As students have had little or no education in the school about solar cells they gave some very informed answers. One example of this is the student who replied to the 'How does a solar cell work?' question with, 'absorbing the sun's rays and turning it into energy' Quite a lot of students knew that the sun was needed to make a cell work and as a result the electricity or energy was used to power things such as lights or machines.

Students appear to be very knowledgeable about what a solar cell can be used for. A lot of these concepts seem to be acquired from what they have seen round them in their local environment eg. solar cars (NT solar car race, lights (solar powered public street lights near the beaches around Darwin), telephones (Telecom commercials on TV). They also included hot water systems which they see on house rooftops everyday The reason why these were included would most probably be because of their shiny metallic panels and the media portraying them as cutting electricity bills.

Students in the class studied show through their responses that the range of knowledge about solar cells is large. It is interesting to note that the majority of these students have been classmates for seven years This would mean that they have all had similar educational exposure through subjects and teachers. This then tells us that their varied range of concepts could be attributed to areas outside the school for example the media. It is also a possibility that particular students retain previously learned concepts more easily than others.

The children do have a good background of other concepts relating to solar cells. They seem to have a partial idea of how a solar cell works and what it can be used for but students appear to have an incomplete idea of the process involved in the workings of a cell.

MISCONCEPTIONS

Students involved in this research gave some interesting responses. They showed a number or misconceptions about how solar cells worked, what they were and what they were made of and their uses. The misconceptions ranged from one student stating that a solar cell was 'like a greenhouse but different' to another saying that a cell was made from 'ultra violet rays and rocks and atmosphere'. These two responses illustrate how diverse and misconstrued

children's concepts can be. However given a chance these students may be able to explain why they gave these answers and how they can be justified in relation to the question. The main area where students had little knowledge was concerning what a solar cell was and what it was made of. Some students explained how it worked, leading me to believe that they could not conceptualise what it was, but could only state a smaller part of the concept.

The major misconceptions that this group of students have are concerning what a solar cell is, in a physical sense, and what it is made of. These are the areas where students need to be educated in order for them to gain the full idea of what a solar cell is.

THE VIDEO

Prior to making the video, in order to further identify the misconceptions, students were given the following words and asked to arrange them as a concept map, showing how they related to each other. SUN, ELECTRICITY, SOLAR CELLS, RAYS, CHANGE. These can be found in Appendix 1.

It seems that students in this study group have a basic knowledge of the concepts related to solar cells but at the same time it is evident that a lot of students have misconceptions about the topic. It was decided to produce a video that explained the main features of solar cells . The aim of this audio visual teaching aid is to teach students about solar cells, by answering the same four major questions, that were originally posed.

In planning the content of the video these questions had to be answered in such a way that the students could comprehend what was happening and would be entertained at the same time. It was quite easy to show students what a solar cell actually was by simply videoing one.

To teach students what a cell was made of was just a matter of a student explaining this orally with the aid of a solar cell. This was explained further with a picture /model of unrefined silicon. Examples, such as calculators, of what a cell can be used for are plentiful in the school environment.

The biggest problem in making the video was explaining how a solar cell worked. Because we cannot actually see the process of a cell making electricity it is hard to teach this concept. I overcame this obstacle by physically representing the exchange of electrons inside a cell by using children as the two types of silicon in the solar cell and balls as the two types of elements added to each wafer of silicon.

A large ball representing the photons was thrown between two lines of students representing the solar cell. Other students representing electrons were released by the plates of the cell. Students could then see something physically moving inside the cell and moving around wire creating a circuit. This modelled the action of a solar cell in a simple way.

Lastly students in groups used the solar cells attached imaginatively to various devices, such as electric motors, to perform a number of useful tasks, such as opening a castle drawbridge etc. They were videoed showing how well these various tasks worked. This provided a diverse range of inventions and a great insight into what solar cells could be used for. The video was later viewed in the class.

OUTCOMES

After viewing the video students were again asked to complete a question sheet containing the same four questions previously mentioned. The reason for asking the class to do the sheet again was to compare results and make a judgment as to whether students could answer the questions more confidently and accurately.

As sheets were collected it was plain to see that the length of responses was far greater than the previous ones. It was also observed that the quality of English expression used improved markedly. This indicated that students were more confident in their responses and had increased their knowledge of solar cells. Although one must be cautious about generalisation, this instance does show the power of methods, that focus on finding out what the children's misconceptions are and then focussing teaching to overcome them.

RESPONSES AFTER THE VIDEO

Student responses follow under each of the questions.

QUESTION WHAT IS A SOLAR CELL?

* a solar cell is a device which uses the sun's heat to create electricity. It does this by having two layers of silicon, one which is called P-type silicon. Boron is added to the P-type silicon so that it has a positive charge because phosphorus is added which gives it a negative charge.
* a solar cell is something which produces energy and makes energy for other electrical things.
* a solar cell is a silvery rectangular piece with a negative side to it and a positive side to it. You can join another cell to it by the "N" and "P" wires. When the sun is up the solar cell goes as fast as it can and when the sun is down it doesn't go at all. When a cloud is covering it, it goes slower.

* it is a panel that uses the sun's light to make electricity or energy. The energy is then used to make something run or work.
* it is something that is powered by the sun which enables the electrical device attached to it to work.
* a solar cell is made of two panels that use the sun's energy to work an object like a calculator, watch and boat.
* it's a rectangular panel which has two silicon crystals. Negative and Positive crystals. Boron is added. Foil is put in the back so the heat reflects onto the screws that the wires are connected to. This makes electricity.
* It is an object powered by the sun to produce electricity.
* it is a crystal silicon with a positive and a negative charge and uses the sun's heat rays.
* a solar cell is made from a thin layer of boron and phosphorus, when the sun shines on the cell it creates electricity for electrical objects. A solar cell looks like a rectangular shape with two wires from it.
*it is a panel which is empowered by the sun in order to produce electricity or to make something work.
* it is a thing with a plastic base and with a top that looks like a mirror. A solar cell is very expensive but good in giving us electricity.
* it is something that the sun hits a panel of a negative and a positive charge to make the motor work and turns the thing on at the end of the motor and goes back to the cell.
* two layers of pure silicon mixed with boron and phosphorus. When exposed to the sun, it creates a neutral cell and can then power many electrical devices.
* It's a solar cell that is made up of b and p. B stands for - and P stands for +.
* It is a long rectangular box with silicon on top of the cell so when the rays hit them they make electricity.
* a cell that collects the sun's energy to run most items that need electricity. It looks like a small rectangular spacey disk with two wires that connect to the item that needs electricity.
* it is a panel that uses the suns light to run on.
*a solar panel or cell is powered by the sun's heat. It has two connections at the back of it and a silvery sort of look.
* It's a rectangular object made from two layers of silicon crystal which is the chief component of sand. We call these layers 'P' and 'N' type silicon.
* a solar cell is a panel which converts the sun's light into energy.

QUESTION: WHAT CAN WE USE A SOLAR CELL FOR?
* you can use it for powering almost any electrical device. It just depends on how big the cell is.
* you can use it for a watch, car, telephone, light, calculator.
* solar cells are usually used to run items run by electricity made from fossil fuels, they can run most small items and even cars.

* you can use it for many things like a car, boat, telephone, lighthouse, draw-bridge and many other things.
* for telephone, boats, cars, watch.
* you can make a solar cell into a panel of cells and when the sun shines on it, the electricity made can power things like cars, phones, calculators, watches and many other things.
* cars, telephones, toys, hair drier, watch, calculator.
* you can use it for cars, boats, air-cons, cranes and other things that need wheels or fans.
* you can use a solar cell for many things, a fan, a watch a, calculator, phone or solar powered cars.
* to run a motor or a light by using the sun's light to create electricity.
* telephone, boat, fan, crane, air-con, light-house.
* a solar cell can be used to run electricity when the sun's rays hit between the two layers.
* to power up things such as a watch, calculator and even a car or phone.
* to work things like a solar watch and a solar car, to reduce air pollution. It doesn't let out smoke.
* to power a telephone, car and many other things that are powered by electricity. However you would need an extremely large panel to power ordinary things.
* to power a car, phone, watch, toys and other inventions.
* for mini boats, cars, phones, air-cons, basically anything that needs electricity or an engine. In the future maybe a car with a solar cell.
* an electric guitar, cars, phones, light-house and Ferris wheel.
* for many different things, motors, lights and hot water systems can all be powered by solar power.
* powering fans, cars, phones, watches, lifts, motors, cranes and even air- cons
* you can use a solar cell to run almost anything with a motor or power box, from boats to swimming crocodiles. You can make anything from them.

QUESTION: HOW DOES A SOLAR CELL WORK?
* a solar cell is run by the sun, when the sun's rays hit between the two layers of silicon they bounce off them and if you add wires and a fan the electricity produced by the silicon travels through the wires to the fan.
* it works when the sun's light hits the cell it excites the electrons and makes a flow of electricity. The wires carry the energy to what it is powering.
* by using the p" type silicon and the "n" type silicon, when the sun heats these two silicons connect and electricity is made.
* the sun makes the positive and negative bounce on the walls and go through one wire go to the thing that needs the energy and comes back in the other wire.

* it works by two wires joined to a positive and a negative, when the sun is up it goes as fast as it can but as the sun goes down it gets weak because the sun is slowly going away.
* the sun's light hits the solar panel which combines the two silicons together which travel through the wires then they hit a fan making it turn and then travel through another wire back to the cell when there is no sun it doesn't work, when there is a little sun it works slowly.
* when the sun hits between the two layers it powers the cells the layers cancel each other out which then powers the objects and it then returns to the cell.
* it works from the power or heat from the sun. When the sun comes along the 'n' and 'p' type silicon work together to produce electricity.
* it works by the 'n' and pw type silicon crystals that make reactions when they have contact with the sun. This makes electricity which goes through the wires to the terminals or a motor.
* the two layers (one negative and one positive) are exposed to the sun, they cancel each other out to make a neutral cell which travels through the wire connected on to it which makes the motor work, through the other wire and back to the cell.
* it uses the suns rays to heat the crystal and it sends a positive and negative which runs through the wires which returns back to the cell passing through the motor.
* by using the sun's light which shines on the cell to create electricity. The sun shines on the two layers, boron and one phosphorus to create electricity.
* the sun penetrates the cell which excites the two silicons making electrons and once the wires are connected to the cell the silicon travels through the wire and back to the cell. During this procedure electricity is made.
* a solar cell works from the sun's power. The sun's rays go through the solar cell and through one wire connected to an engine on the left or right and on another wire to go back to the cell.
* the sun hits the panel and makes the sides (negative and positive) mix and goes around wires to the object that's going around and makes it work.
* when a solar cell is exposed to sunlight a neutral cell is produced, the power created can then travel through wires to an electrical device and then back to the solar panel.
* the 'b' and 'p' join together and the sun's power makes an electric current and moves up and down.
* a solar cell works by the suns rays shining on the two pieces of silicon, the 'p' and 'n' type.
* when sunlight and heat penetrate the solar cell causing electrons to go back and forth from one layer of silicon to the other and when wires are connected to an item electricity is made.
* well there is a positive and a negative side with wires and a fan. When the sun hits them they start to work fairly fast, it goes all around. A positive hits a

negative, negative hits a positive which go around to wires and that makes a fan work.
* the cell has two connections, a positive and negative and when a wire is connected to the cell and motor, a fan will run. The heat from the sun makes the cell give electricity.

QUESTION: WHAT IS A SOLAR CELL MADE OF?
* metal, a lot of solar nerves.
* two layers of silicon, one negative and one positive. They cancel out to make a neutral cell.
* silicon
* two layers of silicon one positively charged and one negatively charged. Silicon is made from sand, purified.
* it's made of two pieces of silicon, 'p' type silicon and 'n' type silicon. *The 'p' stands for- positive and the n' stands for negative.
* silicon.
* two layers of pure silicon crystal, mixed with boron and phosphorus
* It's made out of a positive and negative charge. On the outside it has plastic around it and wires hanging out of it.
* it is made out of two different types of silicon, one silicon is called the boron type silicon and the other is called positive type silicon. Silicon is made of sand.
* two layers of silicon which have been purified. The silicon consists of the negative , phosphorus and positive, boron. They cancel each other out to make a neutral cell.
* It's made of one layer of boron and one layer of phosphorus covered by plastic.
* silicon with crystal particles, what's also in there is boron.
* two layers of silicon A negative and positive which cancel each other out to produce electricity.
* negative and positive type silicon crystals and then boron is added Silicon comes from sand.
* two silicons- an 'n' type silicon and a 'p' type silicon. Each type of silicon produces boron. A solar cell is made up of two panels with wires.
* two layers of silicon two layers, a negative and positive charge.
* two layers of silicon. one (boron) positive and one negative they then cancel each other out to make a neutral cell.
* it is made of two positive and negative wires, the wires can join a bigger cell on to it by the positive and negative wires. You just need to join a positive with a negative and it will become more powerful.
* two different types of silicon The types are 'n' type silicon and p' type silicon
* it's made from silicon. This silicon must be pure. This product is found in the sand.

* two layers of silicon one positive and one negative When the sun penetrates the cell as it has now become . the electrons between the layers of silicon become excited and get a flow of electricity
* silicon and plastic, the silicon comes from normal sand.

CONCLUSION

After comparing responses from the class I found that the video had achieved its objective. However it should only be used as a teaching aid and not as a complete package for teaching about solar cells. It is the students being involved in making the video themselves that improves the learning so substantially. Its use with some other group might be very limited.

Even after this learning experience, it was clear that some of the class were still confused or had misconceptions about solar cells, mainly how they worked, but the number and severity of these misconceptions were now much less than prior to making and watching the video.

In general most students can now explain the concepts involved in solar cells confidently as a result of viewing the video. Their knowledge before was very limited with many students unable to respond to questions on the topic. However now the class in general have a greater understanding of the concepts and are able to explain their new found knowledge and ideas on solar cells

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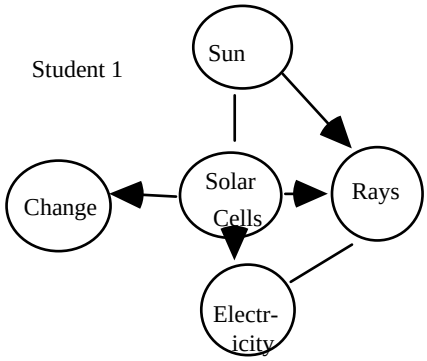
APPENDIX 1 CONCEPT MAPS

Prior to making the video, students were given the following words and asked to arrange them as a concept map, showing how they related to each other. SUN, ELECTRICITY, SOLAR CELLS, RAYS, CHANGE.

Student 1



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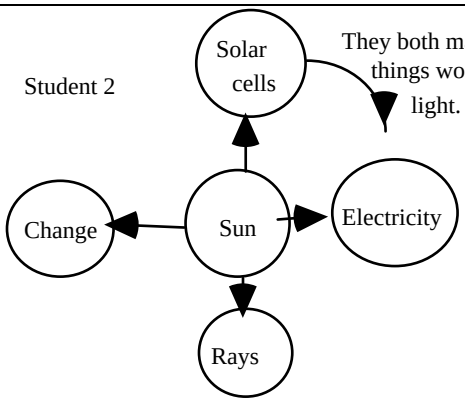

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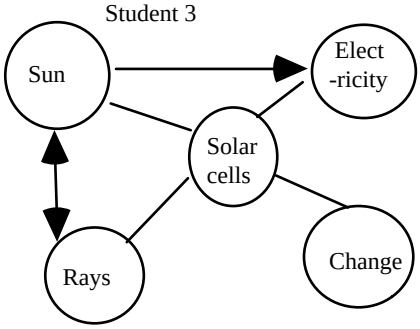

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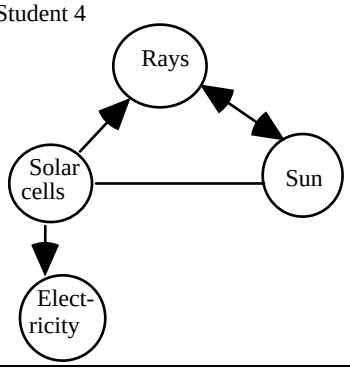

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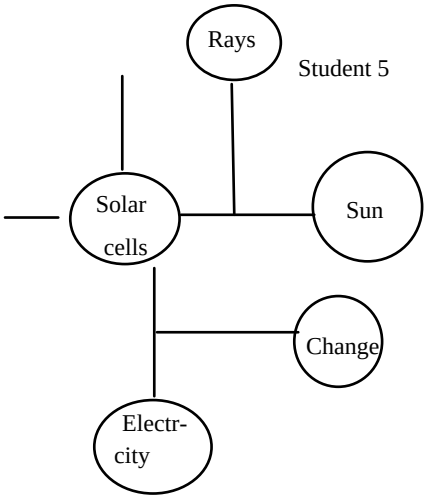

Student 6